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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Steam Railway
Locomotive Lubricants

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

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Steam Railway Locomotive Lubricants

POWER on wheels has become so commonplace that we forget too often just what makes those wheels go around. To be sure, when steam is mentioned, we think of the steam locomotive or, if one speaks of Diesel power, a unique form of internal combustion engine comes to mind which burns a heavier fuel than gasoline and hence requires no ration card. And yet the workings of these engines in railway service are quite comparable with service in stationary power plants. They differ only insofar as space limitations require careful location, more compact piping, perhaps fewer fittings and somewhat smaller accessories.

As far as lubrication is concerned, there also is considerable similarity. Steam super-heated at temperatures in excess of 700 degrees Fahr. requires highly refined steam cylinder or valve oils; the presence of moisture calls for some compounding; and in the Diesel, improved types of bearing metals require the same careful refining of the crankcase oil regardless of its service.

This article is dedicated to the steam locomotive, as one of the most unique mechanical devices ever designed. Figured on the basis of horse power per square foot of area required, the steam locomotive is considerably more concentrated than the average stationary power plant. Within this compact area is assembled all the necessary mechanical equipment to enable maximum utilization of whatever fuel is being converted into steam.

This power plant is mounted on a highly concentrated wheel base and is expected to function under conditions unheard of in stationary power plant operation. In other words, the engine often must run over 100 miles between stops, at high speeds with many of the parts exposed to very heavy and unequal loads, over a roadbed of constantly changing curvature and under all kinds of weather conditions. Yet, throughout this run, the engineer has but little opportunity to observe how most of his bearings are operating and even if he could, there is but little he can do to correct anything which may be wrong.

A road failure is something every operating official wishes to avoid, and even though a hot bearing might develop on a run, all effort is made to bring in the train on time even though minor damage to the bearing might result.

Lubrication of the locomotive involves the use of the following lubricants:

Driving Journal Compounds
Crankpin Greases
Pressure Gun Greases
Ball and Roller Bearing Greases and Oils
Brake Cylinder Lubricants
Air Pump Lubricants
Car and Engine Oils
Hub, Shoe and Wedge Lubricants
Valve Oils
Curve Rail Lubricants and Flange Oils
Headlight Generator Oils
Feed Water Pump Lubricants

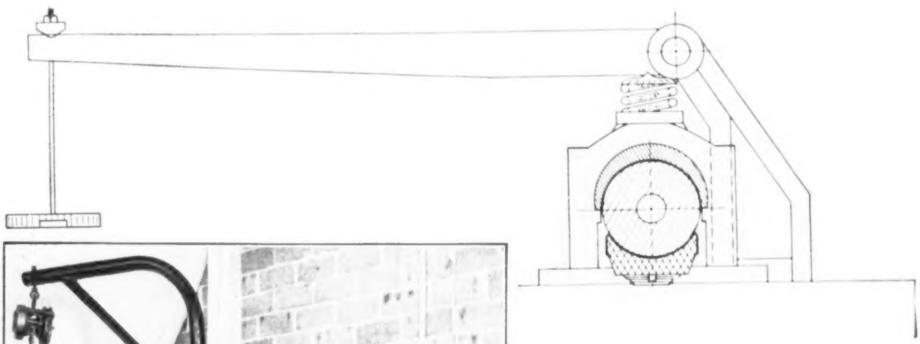
All these lubricants must be possessed of specific characteristics based upon the purpose for which they are intended, the engine design and the means of application. In their develop-

ment road test research has been given equal consideration along with laboratory study. Accordingly, the petroleum technologist must alternate his research between the laboratory and the locomotive in service. The history of most of the successful railroad lubricants today is founded on research of this nature, with volumes of test data, performance charts and mileage records as evidence of the work which has been done.

DRIVING JOURNAL COMPOUNDS

The driving journal bearings are the most critical points on the locomotive regardless of its type. On these bearings is concentrated most of the weight of the locomotive. In addition to this load, the driving journal bearings are subjected to very high rubbing speeds.

It was factors of this nature which developed driving journal research into one of the most intricate problems which has ever confronted the petroleum chemist. From the very beginning he had to realize that it was necessary for him to become intimately familiar with road conditions. Until he acquired full knowledge of the conditions under which a driving journal grease had to function, any laboratory research was unwarranted. It was necessary, therefore, for the progressive oil company chemist to enlist the cooperation of his railway lubricating engineers and the test departments of the railroads. Then the chemist rode in locomotive cabs from coast to coast, over steep mountain ranges, on long hot desert runs, and during the coldest winter weather in the north. All the while he carried test instruments to record bearing and grease temperatures. He recorded grease consumption, noted tendency towards leakage, the nature of the lubricating film and mechanical conditions, all in terms of mileage traveled. Then when he got back to the laboratory he made microscopic studies of grease structure.



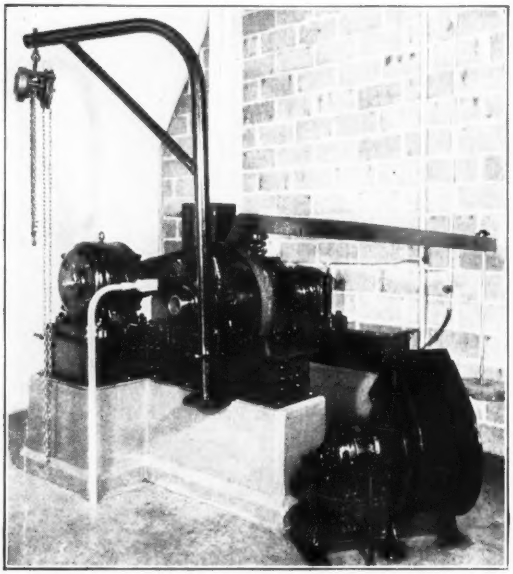


Fig. 1 (above)—Line sketch of The Texas Company driving journal grease testing machine.

Fig. 2 (left)—Laboratory photo of this machine showing motor drive through belt connection, and the lever arm for applying weight or load to the bearing.

With these data available the foresighted oil company then was in a position to build a full-size driving journal grease testing machine in the laboratory. See Figs. 1 and 2. On this machine could be simulated road conditions, temperatures and load. As the temperatures which are developed in driving journals under normal conditions will vary from below zero to about 250 degrees Fahr. during the course of a year, grease research had to be directed toward preparing a product which would lubricate

under both these extremes. When a likely product was developed it was subjected to road tests on locomotives, under the supervision of the railroads' test departments. Performance data were recorded and these records correlated with those obtained on the laboratory driving journal machine.

During this field research it was customary to regard 250 degrees Fahr. as a safe maximum. If bearing temperatures exceeded this figure it was evident that something was wrong, either there were mechanical causes which were influential, such as a pinching crown brass, a tight wedge, unequal weight distribution, etc. or the grease cake was not feeding properly.

In routine service, temperatures in excess of 250 degrees Fahr. are always considered serious; if they are suspected it is advisable to investigate either at train stops or book this for inspection and check up at the engine house.

Desired Properties of the Grease

In considering the desired properties of a lubricating grease to withstand the conditions existing in a driving journal it has often been wrongly thought that high melting point alone was an indication of ability to stay in the cellar without feeding out. Actually many other factors are involved. The grease must be hard enough to stay in the cellar, yet it must be soft enough to permit feeding out to lubricate the journal. The rate of feeding out is not only dependent upon the temperature of the journal, which is caused primarily by the mechanical conditions which prevail for any texture it might show excessive consumption; for example, if it has the tendency to pump out or be fanned out by the action of the rotating journal across the perforated plate. As a case in point, during some of the research a product with the high melting point of 458 degrees Fahr. was found to give a consumption approximately three times greater than one showing a melting point of 435 degrees Fahr. This was found to be due to the fact that the former product tended to be pumped out and fanned out more rapidly than the lower melting point compound.

It was at first thought that hardness of the grease indicated its ability to withstand heat, the thought being that hardness would promote heat resistance when the temperatures of the journal are consistently high. Subsequent research proved that excessive hardness is not desirable since such greases at ordinary temperatures are too hard to feed out properly.

The ideal driving journal grease, therefore, is one which is as soft as possible at normal temperatures and yet retains its body at higher temperatures. If the grease is too hard, it will not start feeding soon enough and may cause damage to the journal and the brass. A softer type of driving journal compound will allow some lubrication even when the journals are cold. By incorporating in lubricants of this latter type the desired heat resistance at higher temperatures the ideal lubricant is obtained. In fact, it is possible to make greases softer than the ordinary driving journal compound at room temperature, yet when heat is applied they will

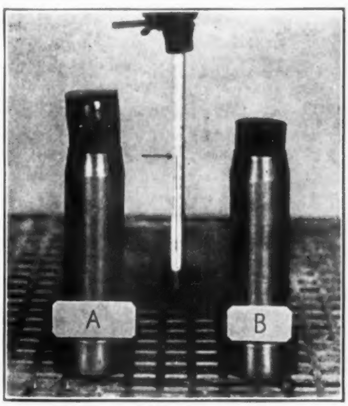


Fig. 3

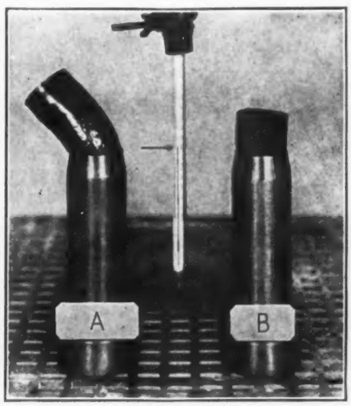


Fig. 4

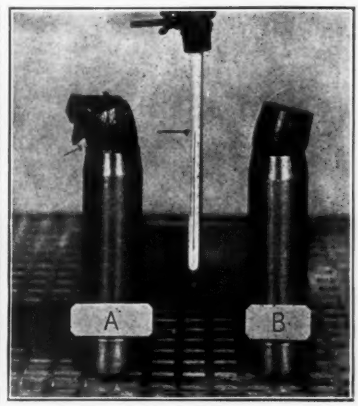


Fig. 5

Figs. 3, 4, 5—Comparative expansion tests on driving journal compounds when subjected to heat. Fig. 3 shows relative expansion at 325 degrees Fahr. Fig. 4 relative expansion at 342 degrees Fahr. Fig. 5 the condition of the greases at 370 degrees Fahr. and termination of test; note sample A has parted under its own weight. Grease B performed best throughout the test. Arrow at thermometer in each figure indicates final temperature.

particular driving journal, but is also dependent upon those physical characteristics of the grease which prevent excessive consumption. In brief, a product may have a very high melting point, yet due to its peculiar structure and actually have more body or consistency than greases which originally were made very hard.

Regarding other factors which are responsible for hot driving boxes one should remember that the heat generated in the average journal and

bearing assembly is due to the mechanical conditions of the assembly. The purpose of the lubricant is to reduce this temperature to a safe operating range. It is true that most greases will serve fairly satisfactorily under mild operating conditions; however, on hot running journals those driving journal compounds which have the highest resistance to heat as well as to pumping action will stay in longer and will permit completion of a run without a set-out. Otherwise a hot box may result before the grease can be replenished. As an example, Grease A in Figures 3, 4 and 5 would have resulted in set-out, whereas Grease B would have brought the locomotive in.

Mechanical Conditions

Of the many possible mechanical causes only a few warrant discussion in this article. One of the most prevalent causes of a hot driving box is a stuck or tight wedge. Wedges should be set to a predetermined clearance and this clearance maintained by the engine house forces. At the same time shoes and wedges should be oiled daily to permit free movement of their contact surfaces which otherwise would become galled or roughened if allowed to run dry. A crown brass which pinches the journal or is loose in the box, a rough journal or a weak follower plate spring are other major causes of hot driving boxes. The most common cause is a distorted perforated plate. The engine crew can assist in keeping hot driving boxes down to a minimum by reporting all journals which have been running above normal temperature to the engine house for inspection at the end of the run. When journals show repeatedly high running temperatures day after day evidently there is something definitely wrong mechanically and the engine house supervision should plan to investigate and eliminate the cause.

CRANK PIN GREASES

Crank pin greases, known also in railroad parlance as rod cup greases, were developed along with driving journal compounds. Here again the petroleum technologist had to incorporate the quality of heat-resistance in his product. At the same time the locomotive designer worked towards improving the design of his pin and bushing assembly.

Accordingly, today, crank pin or rod cup lubrication presents a problem only on roads where engine districts have been extended, speeds increased, and station stops shortened or eliminated. To insure against lack of lubrication under such conditions, the back end of the main rods, also the middle connections should be greased at some intermediate point if the engine is run at top speed for over 400 miles, in order to replenish the original supply of grease to the rods. The same lubricant as used on the driving journals can be used for lubrication of pins.

Modern motive power is, in general, equipped with floating bushings in the back end of each main rod and middle connection. This distributes the load over an increased bearing area and reduces the frictional heat between the moving parts.

Hot pins usually result from fitting the bushings too tightly on the pins or from lack of sufficient lateral. Design of pin and bushing assembly has played an important part in reducing hot pins, bushing renewals and grease consumption.

Fig. 6—Showing corrosion pits on the bottom side of rollers of a locomotive roller bearing, due to water accumulation during a stand-by period.

PRESSURE GUN LUBRICATION

When the pressure grease gun was developed it presented an ideal means for economical application of softer types of grease to the valve motion work. It enabled the engineer to get away from hand oiling with engine oil and relieved him of a tedious routine. With the advent of the pressure gun, however, another problem developed,—that of making a type of grease which would be pumpable in the average pressure gun over a wide range of temperatures. At the same time this grease had to be sufficiently stiff to withstand leakage should running temperatures approach 150 to 160 degrees Fahr. These characteristics were insured by proper compounding of soaps which would render the resultant grease resistant to water, with oils of medium-high viscosity to impart resistance to flow at high temperatures.

Fortunately, the requirements for pressure gun greases developed at about the same time ball and roller bearing lubrication was being studied most intensively. The findings in both cases were helpful in developing the required characteristics in greases for locomotive pressure gun service. One of the most interesting improvements was the high degree of stability or resistance to oxidation which resulted.

Accordingly, pressure gun lubrication affords an effective means of distributing the lubricant over the bearing area and forcing out used lubricant which may have become contaminated. At the same time the new charge of grease forms a seal to prevent entry of moisture, dirt or foreign matter. Bearings which have been greased in the engine house every trip or about every 1000 miles should give little trouble on the road; at the same time wear should be reduced materially.

Fig. 7—The top side of the bearing in Fig. 6, showing absence of corrosion pits,—indicating that water in the low part of the bearing was the contributing factor.

BALL AND ROLLER BEARING LUBRICANTS

Railway ball or roller bearings can be either oil or grease lubricated. The heavy-duty journal roller bearing usually is oil lubricated, the bearing housing being so constructed as to be comparatively oil-tight; accordingly, it is also dust or dirt-tight. A certain amount of moisture can accumulate, however, due to condensation.

The viscosity or body of the oil which should be used depends upon these constructional features, also upon the operating temperature range. Obviously, it is advantageous to use an "all-year" type of oil, although there may be certain conditions of design or such very low temperatures may be experienced in winter as to render it advisable to change to seasonal grades of oil. In any event a railway roller bearing oil should be of high quality, refined from selected crude stock, to accurately controlled viscosity and pour test ranges. The viscosity of such an oil will range from the conventional engine oil viscosity to that of a valve oil according to the type of bearings and the manufacturers' recommendation.

It is important that a roller bearing oil be able to prevent corrosion of the bearing in the presence of moisture. After engines have been washed or have been operated in the rain some water may find its way into the bearing housings. If the engine remains stationary for any length of time the water which settles out may cause rather deep etching of the rollers and race of the bearings. This corrosive action

takes place in a relatively short period of time, for example, it may be only a matter of days.

Corrosion or etching may also occur after the bearing has been drained if sufficient water and oil still remain at the point of contact between

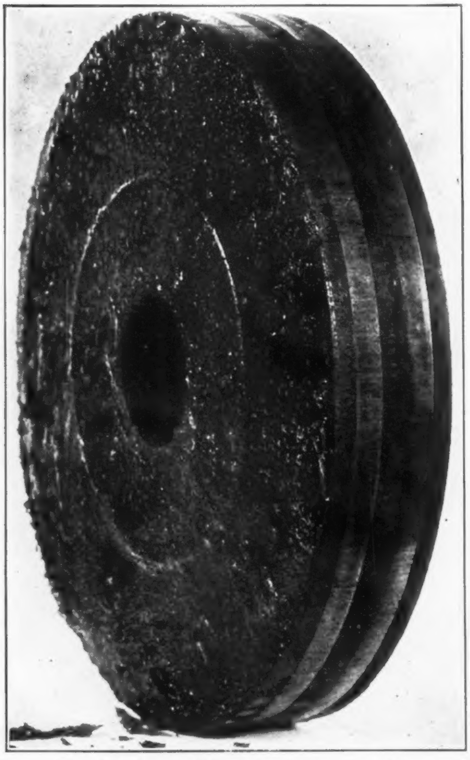


Fig. 8—Showing the condition of a locomotive air pump high pressure piston and rings when a poorly refined oil of too high viscosity has been used.

the rollers and the race to promote this reaction. Figure 6 shows some typical corrosion pits on rollers. It should be pointed out that the corrosion has occurred primarily on the bottom side of the rollers into which the water and oil had drained. The top side of the bearing is practically free from corrosion as can be seen in Figure 7.

Corrosion can be retarded by draining water from the bearings at regular intervals and adding a high quality lubricating oil when make-up is necessary.

It is perfectly practicable, however, to lubricate a journal or rod roller bearing with grease if the design so provides and the grease is adapted to the bearing elements. Some accessory equipment on the locomotive also may be fitted with ball bearings. Normally these bearings are grease lubricated.

This matter of the lubricant being adaptable to the bearing is very important. It was appreciated immediately by the petroleum technologist when he was called upon to perfect lubricants for railway ball and roller bearings. At the same time he had to consider the fluctuating loads which normally prevail, the effects of severe thrusts and considerable torsional or twisting action.

Accordingly, he had to plan his laboratory research with a view to studying load-carrying capacity of suggested lubricants, also their ability to function under wide temperature ranges. This research was fortuitous as it paralleled the development of the "all-year" type of car oil and led to the perfection of a type of grease of like adaptability. By incorporating the added feature of stability there

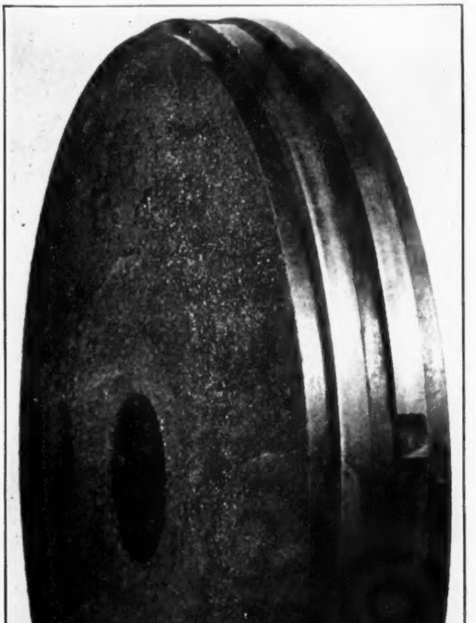


Fig. 9—Use of a suitable oil leads to much cleaner condition of the piston and rings, as compared with Fig. 8.

was made available some most dependable lubricants which can be trusted for their ability to protect the rolling elements of any railway ball or roller bearing.

BRAKE CYLINDER LUBRICATION

A brake cylinder lubricant performs a dual function, viz.:

1. Wear prevention of the metal parts and
2. Preservation of the packing cup over long periods of time.

In considering the type of lubricant required for brake cylinders one must realize that not only must it prevent wear of the metal parts but also it must be water-insoluble, otherwise the moisture in the air which is being compressed would condense and eventually wash off the lubricating film. In addition, the product must be resistant to deterioration since normally it must function for many months without renewal. Cleaning and re-lubrication of the AB brake every three years is set by the A.A.R.

Prior to the advent of the AB brake cylinder the lubricating greases most widely preferred were lime soap products compounded with a rather low viscosity mineral oil, i.e., about 125 seconds Saybolt Universal at 100 degrees Fahr., to which was added a small amount of graphite. In the ordinary lime soap grease (of cup grease nature) the soap and oil are held together by a bond of a small amount of water. If these greases are subjected to sufficient heat to drive off the moisture, the grease will break down to its constituent parts, i.e., soap and oil.

Improvements in brake design, longer periods between regreasing and the necessity for service at wide extremes of operating temperature, however, made it necessary to carry out research to develop extremely stable products. Lubricating greases for AB brake cylinders also had to give greater protection to the packing cups, as these cups must not absorb oil and swell to such an extent as to cause deterioration, although a slight amount of oil adsorption actually tends to preserve the packing cup and offer a better seal. Accordingly, the essential research was planned to embrace two main objectives:

1. Improved heat stability of the grease
2. Better protection and longer life to the packing cup.

It was learned that lime soap greases could be made without moisture by using special compounds to bond or hold the soap and the oil together. In addition, it was found that the life and heat resistance of the grease could be improved by the use of different fats for making the soap than had heretofore been used, which fats had only recently been made available. At the same time the melting point was increased considerably. Evidence of the improvement in the heat stability of such an improved brake cylinder lubricant is given in the following tabulation:

	Old Style Brake Cylinder Lubricant	*New Improved Brake Cylinder Lubricant*
Loss when heated on a six mesh wire screen at 175 degrees Fahr. for seven days..................	85%	none

This method for making lime soap greases without any water being present to hold the grease together is considered one of the important developments in grease research within the past few years.

Regarding the second phase of the problem, i.e., the swelling of the packing cups, research showed that, in general, these cups will swell more when in contact with lower viscosity oils than with higher viscosity oils. This influences

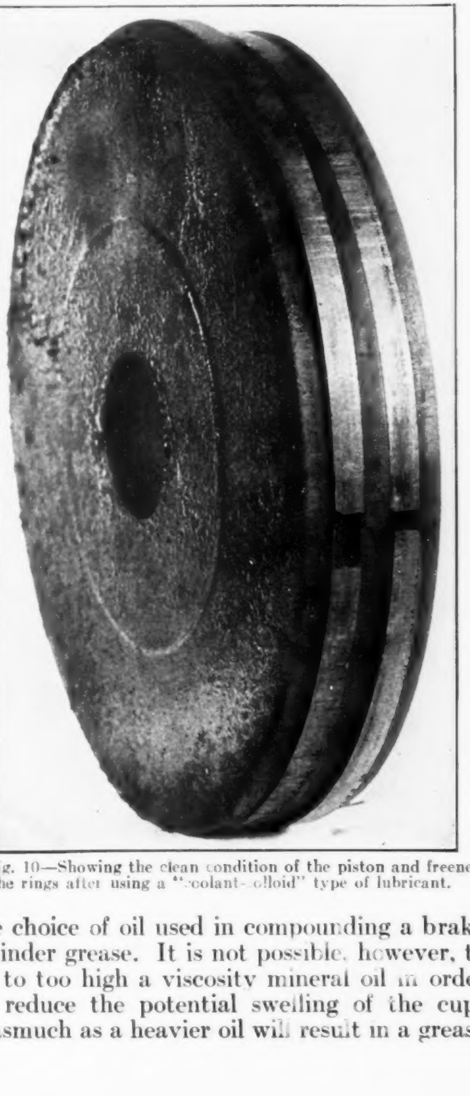


Fig. 10—Showing the clean condition of the piston and freeness of the rings after using a "coolant-colloid" type of lubricant.

the choice of oil used in compounding a brake cylinder grease. It is not possible, however, to go to too high a viscosity mineral oil in order to reduce the potential swelling of the cups inasmuch as a heavier oil will result in a grease

which will cause too much drag at low temperatures. Therefore, an intermediate viscosity must be chosen, high enough to prevent swelling of the cup but low enough to prevent "freezing" of the lubricant.

Some typical data are of interest. For example, after one year's exposure of a packing cup to a mineral oil of 100 seconds Saybolt Universal viscosity at 100 degrees Fahr., the increase in thickness amounted to about 28%; when the viscosity was increased to 600 seconds Saybolt Universal at 100 degrees Fahr., the swelling was reduced to 8%. A Mineral oil having a viscosity of approximately 600 seconds Saybolt Universal at 100 degrees Fahr. and the desired low temperature characteristics appears to be best from the standpoint of protecting the packing cup against excessive swelling. Such an oil will not become too hard at low temperatures. The nature and manner of manufacture of the cup is, of course, also most important.

The following table shows the marked improvement obtained in preventing swelling of the packing cups by the proper choice of ingredients in this new type of brake cylinder lubricant:

	Old Style Brake Cylinder Lubricant	*New Improved Brake Cylinder Lubricant*
Swelling of Packing Cups (Increase in thickness after two years):		
Packing A.	26.0%	4.0%
Packing B.	8.8%	0.5%

AIR PUMP LUBRICATION

The air pump serves the same purpose in steam railway service as the air compressor does in a stationary power plant, i.e., to develop a supply of compressed air for manipulation of other mechanisms. In locomotive operation, air power is used for controlling the brakes, the power reverse, and for operating other accessories such as the whistle and bell. The air pump on the steam locomotive is also similar to the air compressor in stationary service in that it requires but a very small amount of lubrication in its operation.

But here the comparison stops, for railway locomotive air pumps may run much hotter than stationary air compressors. Accordingly,

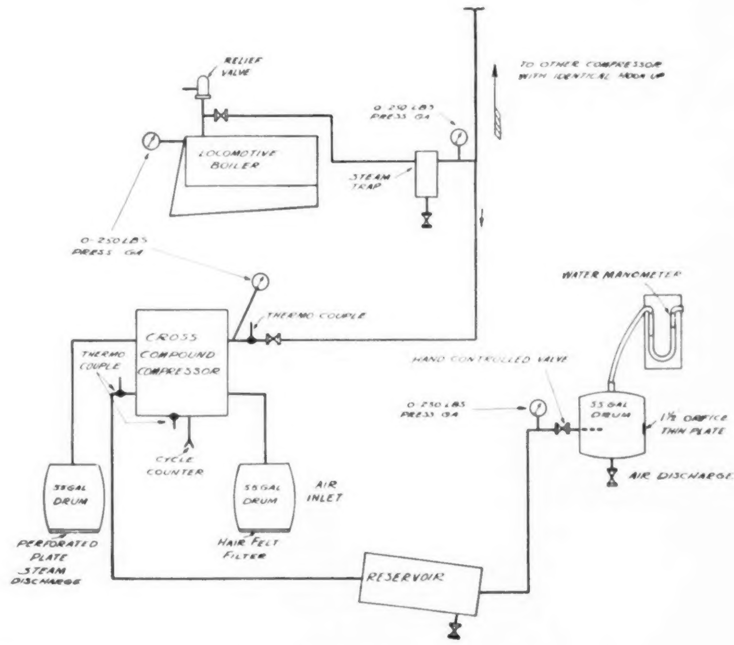


Fig. 11—Arrangement of equipment for testing of air pump lubricants.

the lubrication of a locomotive air pump may present a difficult problem, inasmuch as the very small quantity of lubricant required to maintain lubrication may be subjected not only to extremely high discharge temperatures but also to active oxidizing influences. Temperatures, ranging from 400 to 500 degrees Fahr., normally exist but may go to as high as 800 degrees or more, sometimes reaching red heat.

In general, two classes of lubricants are used:

1. Fluid lubricating oils, and
2. Semi-solid products of the so-called "coolant-colloid" type.

Fluid Oil Lubrication

Straight mineral lubricating oils for locomotive air pump service should be very highly refined, of low carbon-forming tendency, and within a viscosity range which has been proved to be adapted to the means of lubrication available on the locomotives involved.

Roads are now getting away from stock valve oils for the air end of the pump because of the higher carbon residue of these in comparison with oils of lower viscosity which have very much lower carbon residue contents when

properly refined. Figure 8 shows the condition of the piston and piston rings when a poorly refined oil of too high a viscosity had been used. Figure 9, in contrast, shows the much cleaner condition of the piston and rings when an oil of proper viscosity is used. Note that in this latter case, the rings are entirely free.

Semi-Solid Lubricants

The "coolant-colloid" type of air pump lubricant has been the subject of considerable research. It has gained favor due to its behavior when exposed to high temperatures. As mentioned above, the discharge temperature in a locomotive air pump is exceedingly high. Accordingly, the petroleum technologist had to perfect a lubricant which would have sufficient lubricating ability at these temperatures and yet develop a minimum of objectionable deposits. The ideal was a product which would,

1. Act as a coolant to lower the temperature of the air.
2. Permit minimum formation of deposits; such deposits as might be formed being easily removed with water or steam.
3. Act as a cleansing agent to keep the piston rings and compression chamber clean.

In compounding such a product, in addition to the proper viscosity and type of mineral oil, a coolant and a cleansing agent are incorporated. This combination of ingredients must have the proper consistency to permit use either in automatic cups or in mechanical lubricators. One of the significant features of the latest research on this subject has been the discovery of cleansing agents which not only have unusual cleansing action, but also vaporize completely when exposed to high temperatures such as exist in air pumps. In this way the cleansing agent, after performing its task of cleansing the cylinder, pistons, piston rings, etc., is itself completely dissipated and, therefore, does not leave objectionable deposits. Accordingly, the cleansing agent functions as such not only in those portions of the cylinder where deposits tend to accumulate, but in the discharge, where the highest temperatures exist and where an ordinary lubricant would be carbonized. An example of the performance obtained with this type of lubricant is shown in Figure 10. Note that the piston is relatively clean and the rings are entirely free. Figure 11 shows the arrangement of equipment for testing an air pump lubricant.

CAR OR ENGINE OILS

Car or engine oils are used throughout the locomotive for a wide variety of purposes. They are applied to the engine truck, trailer and tender boxes through oil-saturated wool or cotton waste, and sometimes by pad oilers. They are used in stoker and booster crankcases and applied by oil can to valve motion work, guides, spring rigging, brake equalizers and miscellaneous bearings.

In the application of car or engine oil to the various journal boxes and cellars of the locomotive and tender, it is highly desirable that a minimum of make-up oil be used. If the packing is properly prepared, saturated and drained in the oil house and the boxes are packed in the proper manner, it will not be found necessary to use any make-up oil between the engine servicing periods. In other words, the successful lubrication of a waste-packed journal bearing depends upon both the lubricating oil and the waste.

In packing engine truck cellars, trailer and tender boxes, particular care should be exercised by the engine house forces to see that the packing is properly placed so that it will not lose contact with the journal; also to prevent its catching up under the brass and causing a waste grab. See Figure 12. In preparing the waste it must be well mixed, then tumbled to remove lint wipers. Poor mixing will cause waste to roll at higher temperatures; lint wipers will cause waste grab.

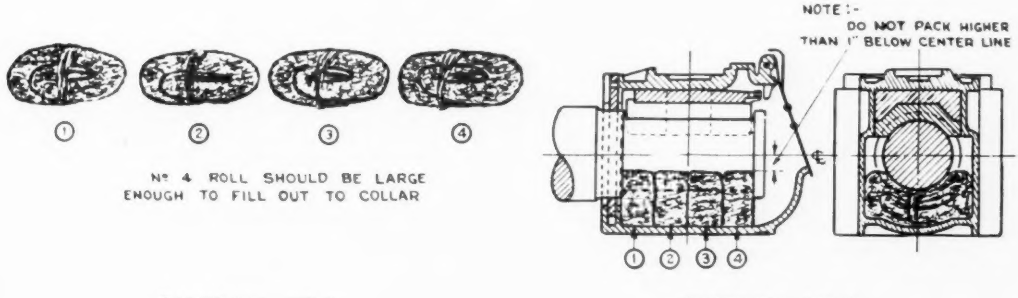


Fig. 12—Showing an effective method of rolling waste (diagram 1); and method of packing a journal box (diagram 2).

In order to determine the best type of car or engine oil for all-around use considerable laboratory research work has been carried out on a car oil testing machine. This machine consists essentially of a set of car wheels mounted in a suitable frame and located in an insulated cold room in order that the whole equipment can be chilled to temperatures as low as minus 50 degrees Fahr. See Figure 13. The sides and ends of the two standard ARA $5\frac{1}{2}''$ x $10''$ journal boxes are cut away as much as possible in order that the action of the waste can be observed more easily. By means of a calibrated spring it is possible to apply as high a load as desired while the machine is being operated at the desired speeds. Temperatures are accurately measured at various significant points, such as:

Bearing—2 points.
Waste—2 points.
Surrounding atmosphere, etc.

For basic information it was desired to know the optimum quantity of oil which should be used per pound of waste. Accordingly, the following data were obtained:

Effect of Quantity of Oil

Run No.	*Pounds of Oil per Pound of Waste*	*Temperature of Failure*
1	2½	—32° F.
2	3	—24° F.
3	3½	+70° F.

It is seen from the above that if too much oil is used failure occurs sooner, i.e., the oil will not function at as low a temperature. These laboratory data as well as field experience indicate that approximately three pounds of oil per pound of waste is maximum.

A study was also made of different types of oils with different types of waste with the following results:

Effect of Type of Waste on Failures with Different Oils

	Temperatures of Failures		
	Oil A	*Oil B*	*Oil C*
Waste X	—32 ° F. failed	No failure @ —50° F.	No failure @ —50° F.
Waste Y	—4° F. failed	—18° F. failed	—40° F. failed

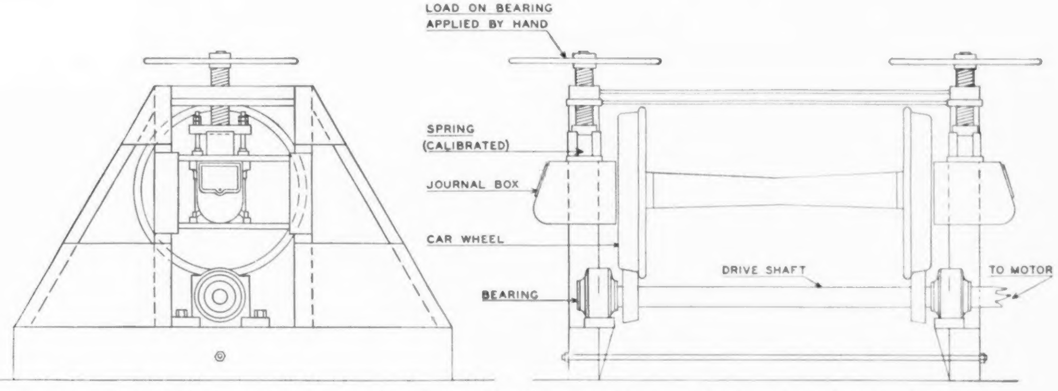


Fig. 13—Details of The Texas Company car oil testing machine (front and side views) showing relative location of parts.

It is seen that oils B & C are far superior to oil A inasmuch as oils B & C gave no failure even at —50° F. whereas oil A failed at —32° F. with waste X. Also it is seen that waste Y gave inferior performance to waste X. As these temperatures are indicative of running conditions in some parts of the country during any winter, it can be appreciated why it used to be thought necessary to have one engine oil for summer use and another for winter use. Research disproved this idea by furnishing data which led to the development of a type of car oil which would be suited to all-year service.

The important characteristics of an all-year car and engine oil involve:

A sufficiently *low* viscosity and body at below freezing temperatures to prevent waste grab and yet a sufficiently *high* viscosity and body at high temperatures to offer proper lubrication and protection to the bearing. In addition, it must be capable of lubricating satisfactorily in the presence of moisture.

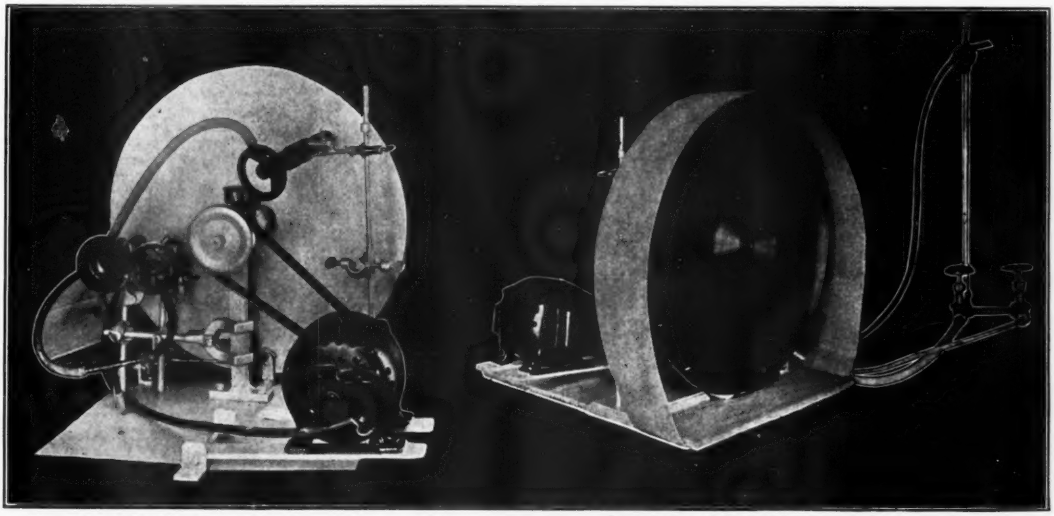
To assure that the combination of a highly refined engine oil and a suitable grade of waste can function dependably in tender and trailer boxes, it is important to prevent water, dust or abrasive foreign matter from contaminating the oil film. This can be accomplished by maintaining a tight box lid together with suitable means for plugging the top of the dust-guard slot, to prevent entry of road-dust, snow and water. It has been found that these contaminants seldom gain entry in or around the space between the dust-guard and wheel-seat, due to the suction action of the wheel which

draws air from the box through the dust-guard opening.

HUB, SHOE AND WEDGE LUBRICATION

Car or engine oils are also suited for such parts as guides, shoes and wedges and driving wheel hubs, being applied by mechanical lubricators. The latter can be placed on either the right or left side of the engine according to the location of the valve oil lubricator, and actuated from the valve motion work. Lubrication applied in this manner is advantageous in that a measured amount of oil is delivered to the frictional surfaces at regular intervals, insuring constant replenishment of the oil film. On roads where mechanical lubricators are installed for valve and cylinder lubrication but where there are no engine oil mechanical lubricators, it is common practice to run feeds from the valve oil lubricator to the top guides. Valve oil is, however, more expensive than car or engine oil so it should not be used too extensively to lubricate parts which can be served just as well by engine oil.

For hand application to driving wheel hubs, fairly viscous straight mineral oils of around 1000 seconds viscosity at 210 degrees Fahr. are preferred, on account of their ability to stick to the hub faces. Particular attention should be paid to hub lubrication especially on roads with a high degree of curvature on account of the lateral loading which may cause considerable wear on these surfaces. It is far cheaper to apply oil than to drop wheels to correct excessive lateral which has developed from hub liner wear.



Figs. 14 and 15—Details of The Texas Company laboratory testing machine for studying performance of curve rail lubricants. Fig. 14 shows the motor drive for the rotating disc, and the gas burners for applying heat. Fig. 15 shows how the disc is housed to prevent slinging of lubricant and water.

VALVE OILS

The development of locomotive valve oils has required continued consideration of the progressive increase in steam temperatures and rubbing speeds. In other words, ordinary steam cylinder oils do not suffice; the refiner must apply the principles of close fractionation for the resultant oil must flow at low temperatures and resist breakdown or partial distillation at high temperatures. Then he has to evaluate the emulsifying ability of various animal fats which are available for compounding.

Compounding

Compounding is necessary even though locomotive valve oils are subjected to extremely high temperature conditions. During the course of expansion of the steam a certain amount of condensation develops in the cylinders which necessitates strengthening of the oil film by the presence of a small amount of animal compound which will emulsify with this moisture. As a result, locomotive valve oils will commonly contain from 3% to 5% of a fatty oil compound such as acidless tallow.

As the degree of superheat has been raised, however, and as insulating materials have been perfected, the possibility of condensation has been reduced. This, together with improvement in methods of treating boiler feed water, has enabled some railroads operating on very high superheat to lubricate satisfactorily with a highly refined straight mineral valve oil or one containing less than 3% compound.

Method of Application

A valve oil is injected either directly into

the steam pipe above the valve chamber or divided between the steam line and steam cylinder. The oil is fed to the valves and cylinders either from a hydrostatic lubricator located in the cab, or from a mechanical lubricator actuated by the valve motion. In any case, the oil is exposed to the temperature of the steam. On the modern locomotive using highly superheated steam this temperature may range in excess of 700 degrees Fahr. This means that a good superheat valve oil must be so manufactured as to withstand abnormal vaporization under these temperatures.

In addition, the oil must be resistant to oxidation and carbon formation as under certain conditions air may be introduced. This makes it mandatory upon the engineer to see that he does not create a vacuum in his cylinders as otherwise front end gases containing a large amount of air, dirt and cinders will be drawn in, or fresh air containing oxygen might enter through the relief valve in which case the oil would deteriorate rapidly. With a throttle operated in a cracked position when drifting or coming into station stops, or where the engine is equipped with a drifting valve, there is but little probability of air entering the valve chamber and cylinders.

CURVE RAIL LUBRICATION

Considerable success has been obtained through the use of lubricating grease or oil applied from the track to the flanges of all the wheels of the train. This lubricant is pumped automatically from a lubricator located alongside the track, flowing to a wiping bar or jet from which it is picked up by the wheel flange. Statistics have shown that driving wheel flange wear can be materially reduced through the use of these so-called "curve-rail" lubricants.

Interest in this phase of lubrication was aroused a number of years ago when records of rail renewal were studied. In cases where curves were located on steep grades and the wheels developed abnormally high temperatures due to continuous braking it was noted that rails in some instances had to be renewed every few months. This justified investigations of means of applying a lubricant of heat resistant characteristics which would protect the rails against wear under these high temperature conditions.

Accordingly, the petroleum technologist developed the laboratory testing machine, as shown in Figures 14 and 15. The purpose of this device was to determine the resistance to heat as well as to water washing of lubricants. As shown, this tester consisted of a 22-inch smooth-faced metal disc which could be revolved at 815 r.p.m. to give the same centrifugal force as exists on the flange of a 32-inch car wheel at a train speed of 64 miles per hour, even though this speed was considerably in excess of the normal downhill speeds of trains. To apply heat to the disc, gas burners were used and in addition a 1/16 inch nozzle was adjusted to permit spraying of water. Thus, both "heat" and "wet" tests could be run. Temperatures of 800 degrees Fahr. and higher were used to anticipate the most extreme conditions of operation.

In addition to heat and water resistance it is of course necessary that these lubricants be pumpable at very low temperatures; for example, at —10 degrees Fahr. or lower. Also when the product is pumped by the lubricator it must have the proper consistency to form a "bead" along the sides of the rail so that it can be picked up by the wheel flanges. It must also be sufficiently adhesive to stick to the hot flanges and be carried along the rail. In fact, curve rail greases have been made which will carry along the track for 10, 15, or 20 miles. In some cases a satisfactory product will be deposited on curves 40 or 50 miles distant from the lubricator. On the other hand, an unsatisfactory product will melt and run down as soon as it touches the hot flange and therefore will not be carried along the curve to protect it for any extensive distance. In addition, the flanges of the locomotive drivers can be lubricated from the cab by means of an automatic oil lubricator.

MISCELLANEOUS LUBRICATION

Under this classification can be included headlight generator oil, train control and speed recorder lubricants, feed water pump lubricant, etc. While but small amounts of these lubricants are used, the parts to which they are applied must be just as carefully protected as the other bearings discussed above.

CONCLUSION

Steam railway motive power is today doing more work than ever before due to the requirements of the war effort. This has placed a most exacting demand upon railway manpower and equipment. There must be less time-out for repair, engines are being dispatched with much less lay-over time than formerly. As a result, repair work and servicing must be concentrated into the time available. This can be assured only by effective lubrication, the application of lubricants which have been specifically prepared for railway service and the use of proper methods, tools and equipment in the engine house.

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